In-Medium strangeness dynamics at $\overline{\mathrm{P}}$ANDA*

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Hypernuclear physics opens a unique opportunity to explore the hyperon-nucleon (YN) and the hyperon-hyperon (YY) in-medium interactions at terrestrial laboratories. Such studies are important for a better understanding of the in-medium interactions with strangeness degree of freedom, which is still uncertain, but of relevance for nuclear astrophysics [1]. The experimental knowledge on multi-strangeness hypernuclei has been so far scarce. However, recent experiments at GSI are very promising. In the HypHI [2] experiment precise production rates of single-Λ ($S = -1$) hypernuclei were measured. An abundant production of double-Λ ($S = -2$) clusters is also expected in the $\overline{\mathrm{P}}$ANDAexperiment [3] at FAIR.

We investigate theoretically the multi-strangeness dynamics within the Giessen-BUU (GiBUU) approach [4]. In particular, we have studied antiproton-induced reactions allowing for reactions of the secondary Ξ-beam on a second target. The formation of double-Λ hypernuclei occurs in the Ξ-interaction with the second target [5]. Two issues are of importance for the production of double-strangeness hypermatter, see Fig. 1. At first, the absorption of the Ξ-beam inside the target matter decreases with increasing energy. This is due to the strong decrease of the elementary $\Xi N \to \Lambda\Lambda$ channel [5]. Secondly, the abundance of bound Λ-hyperons also strongly decreases with rising incident Ξ-energy. This is mainly due to the repulsive vector field which becomes more pronounced as the particle energy increases. These effects lead to a rather strong energy dependent rise of the double-Λ hypernuclear production cross section. Thus low-energetic cascade beams should be used at $\overline{\mathrm{P}}$ANDAin order to obtain high production rates of double-strangeness hyperfragments [5].

So far bare interactions for elementary YN, YY-channels have been used in transport approaches. However, at $\overline{\mathrm{P}}$ANDAthe strangeness dynamics takes place at densities closely up to saturation. We have studied in-medium effects on various YN-processes by solving the Lippmann-Schwinger equation with a Pauli-exclusion operator for intermediate states as the leading-order in-medium effect [6, 7]. The elementary YN cross sections are indeed influenced by in-medium effects, in particular, at low energies, as shown in Fig. 2 (similar effects occur for quasi-elastic channels with strangeness exchange).

In the S=-2 sector the situation is still very controversial theoretically [8]. Presently we are investigating the influence of various calculations on S=-2-channels [9] on the strangeness production in $\bar{p}$-induced reactions and extending our studies to the S=-3 sector by accounting for the formation of Ω-baryons [10]. The preliminary results are very promising concerning a possible formation of multi-strangeness bound systems at $\overline{\mathrm{P}}$ANDA. We emphasize the relevance of our theoretical results for the future activities at FAIR.

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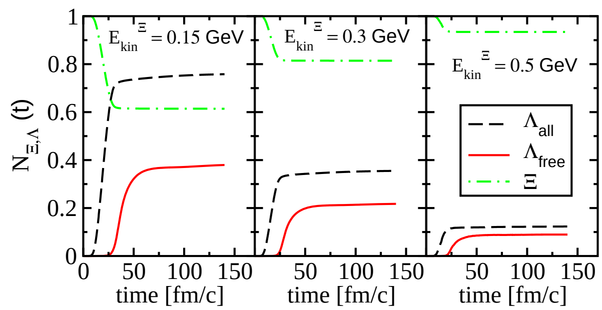

Figure 1: GiBUU results for the time dependence of all and free Λs and of Ξs for central Ξ-induced reactions on Cu-target at beam energies as indicated [5].

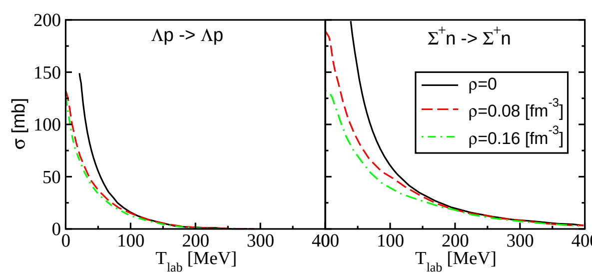

Figure 2: . Energy dependence of elastic in-medium cross sections for ΛN and ΣN scattering at various densities as indicated [7].

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